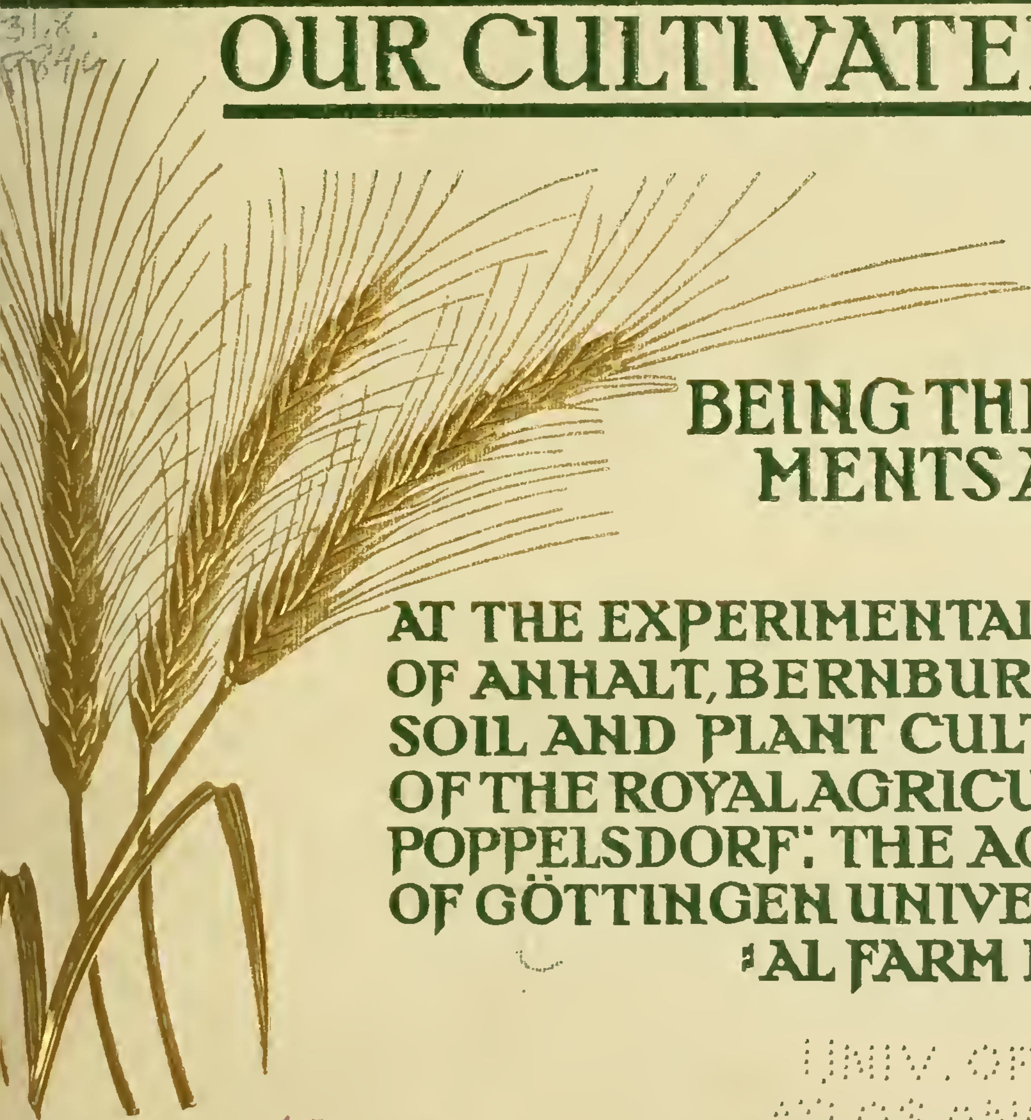
NDICATIONS OF FOOD STARVATION IN OUR CULTIVATED PLANTS



BEING THE RESULTS OF EXPERIMENTS AND OBSERVATIONS

AT THE EXPERIMENTAL STATION OF THE DUCHY OF ANHALT, BERNBURG: THE INSTITUTE FOR SOIL AND PLANT CULTIVATION INSTRUCTION OF THE ROYAL AGRICULTURAL COLLEGE, BONN-POPPELSDORF: THE AGRICULTURAL INSTITUTE OF GÖTTINGEN UNIVERSITY: THE EXPERIMENTAL FARM LAUCHSTÄDT.

ISSUED BY THE POTASH SYNDICATE

Indications of Food Starvation in our Cultivated Plants.

Being the results of experiments and observations

at the Experimental Station of the Duchy of Anhalt, Bernburg: The Institute for Soil and Plant Cultivation Instruction of the Royal Agricultural College, Bonn-Poppelsdorf: The Agricultural Institute of Goettingen University: The Experimental Farm, Lauchstädt.

Issued by the Potash Syndicate.

Printed by
Dr. Selle & Co., G. m. b. H., Berlin
and W. Büxenstein, Berlin

PREFACE.

An important branch of Agricultural Research to-day is the study of the food requirements of the various crops. The effects of with-holding one or other of the indispensable food-constituents are characteristic for each crop, and can be demonstrated pictorially from both field and pot-experiments.

Until quite recently, the only method of demonstrating the results of such experiments, was by means of retouched and coloured photographs or by coloured drawings. Each of these methods was liable to inaccuracies and neither of them appeals to us at the present day. With the advance of colour photography and the colour printing processes, however, we are to-day in a position to procure reproductions in natural colours, which ought to cast no doubt as to their accuracy for illustrating such experiments as we have under consideration in the following pages.

The present work is an attempt to portray, by means of these new processes, the effects of starvation, due to with-holding the several necessary food-constituents, on various crops. The experiments demonstrated were carried out by several of the leading Agricultural Experiment Stations in Germany.

The Agricultural World as a whole, and no less we ourselves, owe a great deal to those eminent Scientists who have imparted to us in these pages, their knowledge concerning some of the problems of plant-nourishment as shown by experiment. To Professor Krüger, Bernburg; Professor Remy, Bonn-Poppelsdorf; Professor Schneidewind, Halle a. S.; and Geheimer Regierungs-Rat Professor von Seelhorst, Göttingen., we extend our heartiest thanks.

KALISYNDIKAT G. m. b. H.
Agricultural Department.

CONTENTS

Signs of Plant-food Starvation

According to the

Experiments of the Experimental Station of the Duchy of Anhalt, Bernburg.

By Professor W. Krueger and Professor G. Wimmer.

The experiments here depicted and described have been conducted partly in Culture Pots and partly on the Experimental Field of the Bernburg Experimental Station. Of the vegetation experiments, those with grass were conducted in soil, the others in a mixture, very poor in plant food, of sand along with 6% purified mould. The field experiments are permanent experiments and the photographs represent the yields, in the case of wheat and potatoes as the results of 1912. On account of the unfavourable weather conditions – in the case of the potatoes, the seed in addition was found to be bad – the crops of 1912 were poor in this locality and the changes on the plants, caused by the various dressings have thereby not been influenced.

Accompanying the photographs of the crop of 1913, the yields are given.

Summer wheat.

(Tables 1 and 2).

Variety: Red Bordeaux.

Field Experiment 1912. – Field on the Experimental Station. Strip – G. Plots 2n and 3.

Medium Loam. – Sown 18th March. – Harvested 30th August.

Photographed 5th August 1912.

The rotation on the field is, Sugar-Beet, Barley, Potatoes, and Wheat.
The size of the plots is each roughly about $^1/_{12}$ to $^1/_6$ acre.
One part of the plot was treated each year with Potash, 4 cwts 88 lbs and 9 cwts 64 lbs of Kainit, or 1 cwt 66 lbs and 3 cwts 10 lbs of 40% Potash Manure Salts per acre, applied either in Autumn or in Spring; one portion of the plots remains constantly without Potash. For each individual crop the nitrogenous and phosphatic dressings remain exactly the same.
Plot 3 on Table 1 has been without Potash since 1902, plot 2n received from 1902 till 1906 yearly about 4 cwts 88 lbs and since 1906 9 cwts 64 lbs. Kainit, applied always in Spring. A few years after the commencement of the experiment, all plants on plot 3 showed marked signs of the lack of Potash, and this became accentuated each year. This lack of Potash was seen in the case of Summer Wheat, — as well as on all the cereal crops, — at first by a retardation in growth, accompanied by later ripening. When the lack of Potash was small, this was scarcely noticeable. When the plots received a complete dressing, the plants show a golden colour in the stems and ears, while in the case of a deficiency of Potash, the above have a green or greyish-green appearance. The fresh leaves will, beginning with the oldest, become tinged with brown stripes and finally dry up, without any transitional stage in yellow, with a brown tinge. The greater the lack of Potash the darker will be the colour. The ears ripen darker than in the case of the completely manured. Furthermore the plant is much more liable to lodge when Potash is lacking. This is very clearly shown in Table 1.

Air-dried crop in 1912 from 1 acre.

Plot 2 n	Plot 3
30 cwts 45 lbs grain	29 cwts 45 lbs grain
52 cwts – lbs straw	48 cwts 78 lbs straw

Table 2 shows single ears taken from plots 2 n (completely manured) and Table 3 (without Potash) shortly before ripening. (See description to Table 1.)

Italian Rye-Grass.

(Tables 3 and 4.)

Pot Experiments 1912.

Soil taken from the Experimental Field on the Station – Plot G 3 which has received no Potash since 1902.

Sown on 19th April and harvested, first cutting, 24th July; second cutting, 8th October. Photographed on 21st September.

Each pot received a standard dressing of:

3.500 grams Nitrogen (N)	in the form of Nitrate of Calcium
1.775 grams Phosphoric Acid (P_2O_5)	in the form of Monocalcic Phosphate
0.180 grams Magnesia (Mg O)	in the form of Sulphate of Magnesia.

The pot, shown in Table 3, received, besides, 0.776 grams Potash (K_2O) in the form of the Muriate, while pot, shown in Table 4, received no Potash. Richly nourished and thriving grass plants have a soft green colour, while the leaves, when they dry up assume a yellow or a reddish yellow colour with light brown to a brown tone (Table 3.)

Lack of Potash shows itself by the slow growth of the plants and by their maintaining for an astonishingly long time, the dark-green colouring of the leaves. The leaves die down without turning yellow with a dark brown colour. When Potash is almost entirely absent, the leaves show on the still green or delicately yellow coloured leaves, brown stripes or spots before their actual decay.

The average of two control experiments, which were in correspondence, given in grams of dried hay gave the following results:

	1st cut	2nd cut	Part above Soil	Roots	Whole plant
	grams	grams	grams	grams	grams
Table 3 Completely Manured	53.98	43.70	97.68	35.91	133.59
Table 4 Without Potash	44.80	37.05	81.85	25.87	107.72

Tobacco.

(Tables 5 to 7.)

Variety: Geudertheimer.

Pot Experiments 1912.

Soil – Sand with 6% purified mould.

Planted out on June 7th.

The "Trash" (Sandgut) was harvested on the 27th of August.

The "Leaf" (Bestgut) was harvested on the 12th of September.

The results were photographed on 5th August.

Each pot received a dressing of 10 grams Carbonate of lime, 0.120 grams of Magnesia (Mg O) in the form of Magnesium Sulphate, besides a complete mixture of:

2.800 grams	Nitrogen (N)	as Nitrate of Calcium
16.450 grams	Potash (K_2O)	as Sulphate of Potash
0.426 grams	Phosphoric Acid (P_2O_5)	as Monocalcic Phosphate

with Nitrogen deficient, as in complete manuring, but only 0.700 grams Nitrogen (N)
with Potash deficient, as in complete manuring, but only 0.188 grams Potash (K_2O)
with Phosphoric Acid deficient, as in complete manuring, but only 0.142 grams Phosphoric Acid (P_2O_5).

The plants depicted on the tables ripened prematurely and were without tops. Each table shows one of the plants (No. 1) receiving complete manure. With complete manure the tobacco plant shows large, juicy green leaves which turn first into yellow and finally die with a light brown or brown colour. Leaves broken off at the beginning of ripening when normally dried, assume similar colouring, burn well, and smell good. With lack of nutrition the plants are always backwards in growth; the leaves, however, vary in their behaviour according to the nature of the want. With Potash starvation, Table 5, No. 2, the leaves curl inwards towards the lower side and the margins become drawn in, – a feature which varies with the intensity of the Potash deficiency. Before this happens, however, yellow spots begin to appear between the veins on the leaf and these turn soon into brown or grey-white. The leaf margins may also be easily torn. The whole leaf finally dries up a brown colour

without previously turning yellow. When Potash is only slightly deficient, the wrinkles and brown spots are limited to the apex of the leaf. Leaves which are extremely deficient in potash are brittle both in the fresh and in the dry condition. Tobacco poor in Potash, glows badly or not at all and has an unpleasant odour, both of which properties vary according to the intensity of the want.

When there is poverty in the Nitrogenous constituent, Table 6, No. 3, the leaves assume a light green to yellow green colour, but retain at the same time their natural form. They dry always with a light brown colour first turning yellow. The brown colouring becomes lighter as the nitrogen content decreases. Such leaves on the whole, retain quite good glowing properties and good odour, although both of these appear to suffer when the deficiency in nitrogen is great. If Phosphoric Acid is not present in sufficient quantities, Table 7, No. 4, the leaves assume a dark green colour, often with a mixture of a light reddish bronze tint. Small brown patches, for the most part irregularly distributed, appear on the leaves. Finally at the margins, usually first in the neighbourhood of the apex, larger dark brown places show themselves on the leaves, which then dry fairly quickly with a dark brown colour, without any transitional yellow stage. Leaves whose phosphoric acid content is small, are when dry, rather brittle; they are, however of good brand, although the odour suffers.

Crop of dry leaves, average of 2 Control Experiments.

No. 1. Complete Manuring	37.83 grams	No. 3. Nitrogen Starvation	20.09 grams
No. 2. Potash Starvation	30.37 grams	No. 4. Phosphoric Acid Starvation	18.55 grams

Potatoes.

(Tables 8 and 9.)

Variety "Saas".

Field Experiment 1912. Conducted at the Experimental Station. Medium Loam.

Strip K, Plots 5 and 6. Planted on the 27th April.
Lifted on 10th October.
Photographed on 7th August.

Even in the middle of July on plot 6, as on all similar plots, it was noticed that the vegetation was unmistakably dark green, while a normal green colouring was exhibited on plot 5, and the control plots. The leaves on plot 6 exhibited at the beginning of August all those characteristic indications of deficiency in Potash as they are shown on the lower half of Table 9. The leaves of the Potatoes on plot 5 showed in the beginning of August a bright green colour. At the end of August, plot 6 had completely died down, while at this time plot 5 showed without exception still numerous bright green or yellow leaves. The plants on this plot died only in the course of September. In the potato plant the evidences of Potash starvation are as follows. The plants are retarded in growth and retain for a remarkably long time their green colour. The internodes become shortened in comparison with those of normally nourished plants, and the pinnate leaves are closer to one another, than is the case in completely manured plants (Compare

on Table 9 the three normal leaves above from plot 5, with the eight below from the Potash-deficient plot 6.)

The individual leaflets assume a crimpled form similar to those of the Tobacco plant, – also the mid-rib turns inwards towards the under surface – the leaves retain an undulating appearance and yellowish spots which gradually turn brown show between the veins of the leaf, drying up finally dark brown without intermediate yellow.

Such alterations are not exhibited by leaves of normally nourished potato plants. These turn yellow-green to yellow before ripening, and this without any alteration of the leaf form, and finally dry up brown, which is, however, lighter than when Potash is lacking.

Crop of fresh tubers from 1 acre.

Plot 5 with Potash	76 cwts 56 lbs
Plot 6 without Potash	48 cwts 67 lbs

Sugar-Beet.

Pot experiments 1912 (Tables 10–14.)

Variety: Braune's Elite. Seed from 1 seed beet.

Soil: sand and 6% purified mould.

Sown 3rd May.

Harvested in the middle of October.

Table 10. Photographed on 5[th] August.

Table 10 shows the following beets:

1. Complete manuring, with an addition of Nematodes, by means of which, it was demonstrated that in the case of complete manuring, Nematodes have no influence on the outward appearance of the beet.

Manuring:

2.520 grams Nitrogen (N) in the form of Calcium Nitrate

4.230 grams Potash (K_2O) in the form of Muriate or Sulphate of Potash

1.065 grams Phosphoric Acid (P_2O_5) in the form of Mono-and Di-calcic Phosphate

0.400 grams Magnesia (Mg O) in the form of Sulphate of Magnesia

1.110 grams Calcium Chloride as a protection against heart-rot and dry-rot.

2. Manuring as in No. 1, but without Potash. The Potash which was taken up by the plants in this case was very limited and originated from the sand.
3. Manured as in N o.1, but with an addition of only 0.470 grams Potash (K_2O) in the form of Muriate and Sulphate of Potash.

In the completely manured plot No. 1, the beet shows broad and juicy green leaves which are not very undulating, and which, before dying, assume a pure yellow colour, often on one half of the leaf somewhat earlier than on the other. They finally die off a light brown colour. Where Potash is deficient (No. 2, without Potash; No. 3, with small addition of Potash) the tops are relatively vigorous, and if the want is not so large, then at the beginning, one can hardly distinguish them in size from

normally nourished plants, as, in cases of Potash deficiency, there is always a disproportionately large amount of top in comparison with the other parts of the plant. Moreover, this holds good for all plants. As soon as the Potash deficiency begins to show itself, the leaves remain longer green than is the case with sufficient nutrition, then yellow spots appear between the leaf veins and these turn quickly into brown or greybrown, and the whole leaf withers a brown colour without an intermediate yellow. In severe Potash starvation cases, as the photographs show, round longish light brown or dark brown spots appear before the dying off of the leaves on the stalk, as is shewn in the beets on

Table 11, photographed on 7th August;

the beet is manured as beets 3 on Table 10 (Cf. also the beets on Table 14). With Potash starvation the head of the beet plant is often very high. In the beet itself the evidences of lack of Potash are, that the plant remains backward in growth and the sugar content is low. The flesh often becomes yellow, more especially is this the case on the upper half.

Yield per pot. Average of 4 control experiments:

No.	Fresh Beet	Sugar in fresh Beet	Dry Beet	Dried Tops	Total dry substance in Tops
	grams	%	grams	grams	%
2.	50	13.40	10.19	46.53	82.02
3.	317	17.24	70.50	60.68	46.20
1.	431	20.82	118.57	69.60	37.00

Tables 12 and 13. Photographed on 7[th] August.

The Beets depicted on Tables 12 and 13 received a manuring of:

2.520 grams Nitrogen (N)	in the form of Calcium Nitrate
0.470 grams Potash (K_2O)	in the form of Muriate and Sulphate of Potash
1.065 grams Phosphoric Acid (P_2O_5)	in the form of Mono-Bi-Calcic Phosphate
0.400 grams Magnesia (MgO)	in the form of Sulphate of Magnesia

1.160 grams Calcium Chloride as a means of protecting against heart-rot and dry-rot

No. 67 on Table 12 remained without Nematodes

No. 72 on Table 13 received an addition of Nematodes.

For experiments, such as those at present under consideration, the Nematodes are artificially reared in a mixture of sand and mould, very poor in plant food, and can thus be added to the soil of the culture pot in any desired quantity. The moisture in the soil remained normal until the middle of June but then until harvest became very small. The Nematodes take away part of the nourishment from the beets, so that when there is just sufficient amount of plant food for the beet, and if Nematodes are present, a certain deficiency of nutriment must result, and an already existing deficiency will be increased by the effect of the Nematodes. The amount of damage which they cause varies in proportion to the number of nematodes present, also on nourishment of the plant, and on the amount of moisture present in the soil. The infestation with Nematodes being equal on a soil which would have just sufficient nourishment for the beets, if the land was full of Nematodes, the damage done is more extensive in moist soils than in dry.

However, when there is not enough plant food, and particularly so when Potash is decidedly wanting, the harm done in a dry soil is larger, because where there is poverty in moisture the food is less available, a fact which may lead to the early dying of the plant under conditions when Potash is deficient, but where Nitrogen and Phosphoric Acid are wanting, this does not result, be the deficiencies of these ever so large.

It is well known that by manuring heavily with a complete dressing the harm done by Nematodes may be entirely or almost illiminated.

The alterations on the leaf caused by the presence of Nematodes are nothing more or less than the intensified appearances of food starvation as has already been described in the case of Potash deficiency. These appearances concur with what has been said in Nr. 72, with Nematodes on Table 13, stronger than in No. 67, without Nematodes on Table 12.

In beet, the harm done by Nematodes exhibits itself not only by the retardation of growth but also often by a strong lateral root formation and the absence of the tap-root (leggy appearance.)

Yield per Pot. Average of 4 control experiments.

No.	Fresh Beet	Sugar in fresh Beet	Dry Beet	Dry tops
	grams	%	grams	grams
67	290	17.88	71.36	52.74
72	333	16.27	53.49	47.67

Table 14.

This Table shows beet depicted on Table 10 under No. 2, but photographed on 21st September. In this case, the deficiency of Potash had all but reached its highest effect. The beet does not form any more leaves of the customary broad form, but long narrow, lanceolate, somewhat spindle-like twisted leaves, mostly of a very tender nature. These leaves also become finally brown in the same way as always happens where Potash is lacking, often only quicker, and brown spots develop on the leaf stalk. If these leaves grow fairly large, as is the case here, the beet may remain alive even as a weakly nourished plant until the normal harvest time; if the leaves are very small the beet dies prematurely.

In the latter case, the beet assumes a brown colour, beginning at the head, and rots very quickly.

See under Table 10 for the yield.

Field experiments 1913.

(Tables 15 to 20.)

Field of the Experimental Station. Medium Loam, strongly infected with Nematodes.

Sown on 10th April   Crop Harvested 7th November.

Photographed 24th to 26th September.

The Tables give the results of a permanent experiment to estimate the effect

of various manures on the damage wrought by Nematodes. Similar experiments have been for many years conducted by us on various farms with fields badly infested with Nematodes.

In order to admit of the Nematodes having their greatest effect, the crop rotation is fixed as Sugar-Beet, Barley, Sugar-Beet, Barley, etc. The size of the individual plots averages for the most part about an eigth of an acre, and there are always two control plots. The beets receive always the following quantities of manure per acre:

cwts	lbs	Plot 1 (Table 15)	cwts	lbs	Plot 2 (Table 16)
4	88	Nitrate of Soda	1	66	Nitrate of Soda
1	66	40% Potash Manure Salts	1	66	Potash Manure Salts
3	10	Superphosphate (18% P_2O_5)	3	10	Superphosphate (18% P_2O_5)

cwts	lbs	Plot 3 (Table 17)	cwts	lbs	Plot 4 (Table 18)
4	88	Nitrate of Soda	4	88	Nitrate of Soda
3	10	Superphosphate (18% P_2O_5)	1	66	Potash Manure Salts
		No Potash			No Phosphates

cwts	lbs	Plot 5 (Table 19)	cwts	lbs	Plot 6 (Table 20)
4	88	Nitrate of Soda	6	20	Nitrate of Soda
3	10	Potash Manure Salts	3	10	Potash Manure Salts
3	10	Superphosphate (18% P_2O_5)	4	88	Superphosphate (18% P_2O_5)

The manure quantities were somewhat altered in the case of Barley; Plots 3 and 4 remain respectively without Potash and Phosphates. The experiments are for

the present conducted without farmyard manure. This experiment has been in operation since 1910 so that the plots here given, have carried beet twice.
The individual plots shew in general, as also here, the following differences:

Table 15.
(Plot 1.)

The manure quantities supplied would have been just sufficient to cover the plant requirements when no Nematodes would be present.

According to the statements made in connection with the pot experiments, a small deficiency in plant food is bound to set in, which, however, as it mainly falls on the nitrogen, only exhibits itself by means of a smaller vegetation and a somewhat earlier ripening.

Indications of plant food deficiencies manifest themselves with the given amount of manure only in a small way, so that it is often difficult to distinguish definitely. The leaves wither a brown colour after previously turning yellow. The beets are sound and the sugar content normal.

Table 16.
(Plot 2.)

The small application of nitrogen induces about the end of June, quite a marked retardation of growth, and the leaves assume at the same time a light green colour. In the course of the next few months the beets are increasingly more retarded, the leaves becoming light coloured simultaneously. During September and

October, only the youngest leaves are bright green, while the older are yellow green, and all wither up a very light yellowish brown with an intermediate dull yellow colour. The beets are sound and the sugar content is normal.

Table 17.
(Plot 3.)

In sharp contrast to the plants depicted on Table 16, the beets in this case of Potash Starvation do not differ essentially from those on Table 15 during the earlier period of growth.

In July, however, a markedly undulating appearance is noticed on the leaves, the foliage becomes dark green, and in the following months the leaves exhibit sooner or later, according to the weather, the characteristic indications of Potash starvation, as depicted in the pot experiments. The sunshine causes beet, infested with Nematodes to wither easily and this is specially marked where Potash is deficient.

In the field, of course, the individual plants do not resemble one another so closely as in pot experiments: beets with the acutest Potash deficiency are intermingled with some which are only exhibiting the first signs of the want. Here can be seen a beet with only a few quite small leaves, almost dead; there, another with long pointed leaves standing higher, and next it perhaps also one whose leaves can scarcely be distinguished from those of a normal plant. All sorts of intermediate stages are present, so that a field which has a greater deficiency of Potash

always at the time exhibits a very irregularly – developed appearance. In the case where the beets have only small pointed leaves, generally before they dry up, a greater number of the older and more normal leaves have dried up all at once, and now lie round the beet plant making a star form on the ground. Only where there is Potash starvation is this very evident, as by every other manuring, the individual leaves die off slowly one after the other, and the tops which remain strong until the harvest prevents a regular casting of dead leaves on the soil.

If a beet dies prematurely in August or the beginning of September as a result of great deficiency in Potash, the plant disappears very soon, partly or completely from the soil, as it quickly rots. We would point out that such beets have been well named "Consumption" Beets. Lack of Potash always diminishes the percentage of sugar present.

Table 18.

(Plot 4.)

With the absence of Phosphoric Acid, the beets in the soil used for this experiment do not differ in their external development during the first period of growth, from normally nourished plants, when sufficient soil moisture is present. However, if May is dry, the beets with a dark green colour are immediately markedly retarded in growth. These, however, develop on the advent of rain as a rule very rapidly into robust plants, scarcely to be distinguished as far as size is concerned, from normal plants.

The leaves, however, continue to remain deep dark green, and do not dry up as normal plants, brown after a transitional yellow stage. Usually smaller or larger black-green or black-brown spots appear on the leaf veins, mostly in the neighbourhood of the apex, this, after a weakening of the colour, with a light reddish bronze tint. The leaf soon dries up into a deep dark brown or black-green colour, without turning first yellow. Moreover, it sometimes happens that a leaf or part of one after suddenly welting, turns quickly into a colour varying from a dark grey green to a blackish colour. If there is very little phosphoric acid present, the vegetation also is retarded and the leaves assume easily a lying form. These manifestations were all clearly evident in the present experiment during 1913.

Although in the case of phosphoric acid starvation the beets may remain small in size, they are healthy. The sugar content is in general only slightly lowered: however in the case of a greater deficiency of phosphoric acid, should the nitrogen be present, in relatively large surplus, then under certain conditions, the sugar content may be further lowered.

Table 19.

(Plot 5.)

This plot received the same quantities of Nitrogen and Phosphoric Acid as Plot 1, but a much increased quantity of Potash. Under such manuring, the beets grew similar to those on Plot l, but by the advanced growth about August and September, it was evident that the increased Potash had greatly hastened the

ripening. The leaves assume earlier and in greater number than on plot 1, a yellow colour, and dry up mostly with a somewhat lighter colour. The collective appearance is very well depicted by the coloured photographs. In such manuring the beets are sound, sugar content normal, being sometimes somewhat increased.

Table 20.
(Plot 6.)

For this plot, with strong Nitrogen, Phosphoric Acid and Potash manuring, that which was said about the rigidly exact manuring in the pot experiments holds good here. The harm done by Nematodes is best overcome by this method. The development of the plant from the beginning is extraordinarily strong, only luxuriant dark green plants being seen until late summer. If the manuring is rightly measured, which has to be reckoned on the number of Nematodes present, then the leaves become, when the weather is normal, finally yellow, and dry up in a brown colour, and a normal ripening results, although, if the weather is unfavourable, the ripening may be somewhat protracted.

The beets remain healthy and the sugar content is normal. Even if the sugar content is somewhat lessened by frequent protraction of ripening, it is always again compensated for by the high yield of the beets.

Yields 1913.

Average of two Control Plots.

No. of Plot	Fresh Beet per acre		Fresh tops per acre		Sugar in fresh Beet	Sugar yield per acre	
	cwts	lbs	cwts	lbs	%	cwts	lbs
1	205	22	161	22	19.50	40	3
2	172	100	106	0	19.06	32	108
3	199	22	151	0	18.66	37	17
4	184	100	157	56	18.64	34	54
5	226	78	188	78	19.80	44	99
6	254	100	227	89	18.74	47	85

FIELD EXPERIMENT FROM THE EXPERIMENTAL-STATION OF THE DUCHY OF ANHALT, BERNBURG.

(Springwheat).

Plot 3
No Potash.

Plot 2 n.
Complete Manure.

FIELD EXPERIMENTAL FROM THE EXPERIMENTAL STATION OF THE DUCHY OF ANHALT, BERNBURG (Spring Wheat).

No Potash Complete Manuring

Bernburg Table 2

POT-EXPERIMENT FROM THE EXPERIMENTAL STATION

Complete Manure.

OF THE DUCHY OF ANHALT, BERNBURG (Ryegrass).

No Potash.

POT-EXPERIMENT FROM

Insufficient Potash. Complete Manure.

THE EXPERIMENTAL STATION OF THE DUCHY OF

Insufficient Nitrogen. Complete Manure.

FIELD-EXPERIMENT FROM THE EXPERIMENTAL STATION OF THE DUCHY OF ANHALT, BERNBURG (Potatoes).

Plot 6
Potash.
... and ...
... (compound ...
... ete Manure)

Plot 5
Complete Manure.

ANHALT, BERNBURG (Tobacco)

Insufficient Phosphoric acid. C...

ELD-EXPERIMENT FROM THE EXPERIMENTAL STATION OF THE DUCHY OF ANHALT, BERNBURG (POTATO-LEAVES).

The 3 topmost leaves belong to plot 5 (Complete Manure), the others to plot 6 (Potash starvation) vide Table 8.

POT-EXPERIMENT FROM THE EXPERIMENTAL STATION OF THE DUCHY OF ANHALT, BERNBURG.

(Sugar Beet)

No Potash

Strong Dose of Potash

Weak Dose of Potash

POT EXPERIMENT FROM THE EXPERIMENTAL STATION OF THE DUCHY OF ANHALT, BERNBURG (Sugar Beet).

Application of Potash Insufficient

POT-EXPERIMENT FROM

Limited Soil Moisture.
Weak application of Potash.
No nematodes

THE EXPERIMENTAL STATION OF THE DUCHY OF ANHALT, BERNBURG (Sugar beet)

Limited Soil Moisture.
Weak application of Potash.
With nematodes

N

FIELD-EXPERIMENT FROM

Plot 1
Complete Manure.

Manuring per acre

4 cwts	88 lbs	Nitrate of Soda	
1 „	66 „	40 % Potash Manure Salts	
3 „	10 „	Superphosphate (18 % P_2O_5)	

THE EXPERIMENTAL STATION OF THE DUCHY OF ANHALT, BERNBURG (Sugar beet)

Plot 2
Nitrogen starvation.

Manuring per acre
wts 66 lbs Nitrate of Soda
... 6 .. 40 Potash Manure Salts
... Superphosphate (18 P O)

Plot ...
Potash sta...

Manuring p...
4 cwts 88 lbs Nitrate ...
3 .. 10 .. Superph...

FIELD-EXPERIMENT FRON

Plot 4
Phosphoric acid starvation.

Manuring per acre

4 cwts 88 lbs Nitrate of Soda
1 cwt 66 „ 40% Potash Manure Salts

B ble 18

THE EXPERIMENTAL STATION OF THE DUCHY OF ANHALT, BERNBURG (Sugar beet).

Plot 5

Potash in excess.

Manuring per acre

4 cwts 56 lbs Nitrate of Soda

3 „ 10 „ 40 Potash Manure Salts

[illegible] „ 10 „ Superphosphate (18 P O)

Pl

Excessive ma

Manuring per a

6 cwts 20 lbs Nitrate of S

3 „ 10 „ 40 Potash Man

4 „ 88 „ Superphosphate (18

Explanation
of Photographs from the Experimental Field of the Royal Agricultural Academy, Bonn-Poppelsdorf.

Prof. Th. Remy, Bonn.

These colour photographs taken in June, 1912, are illustrative of three beds of a permanent manurial experiment, conducted since 1906 on the following plan:

<table>
<tr><th>Bed
No.</th><th>I.
Sugar beet</th><th>II.
Oats</th><th>III.
Rye</th><th>IV.
Potatoes</th><th>V.
Peas</th></tr>
<tr><td rowspan="4">14</td><td colspan="5">Complete manure consisting of:</td></tr>
<tr><td>132 lbs. phosphoric acid as Superphosphate</td><td colspan="2">132 lbs. phosphoric acid as Superphosphate</td><td>132 lbs. phosphoric acid as Superphosphate</td><td>132 lbs. phosphoric acid as Superphosphate</td></tr>
<tr><td>264 lbs. potash as Kainite</td><td colspan="2">264 lbs. potash as Kainite</td><td>264 lbs. potash as Potash Manure Salt (40%)</td><td>264 lbs. potash as Kainite.</td></tr>
<tr><td>132 lbs. nitrogen as Nitrate of Soda</td><td colspan="2">264 lbs. nitrogen as Nitrate of Soda</td><td>66 lbs. nitrogen as Nitrate of Soda</td><td>5,5C0 lbs. Burnt Lime.</td></tr>
<tr><td>8</td><td colspan="5">Some as bed 14, but without potash.</td></tr>
<tr><td>3</td><td colspan="5">No manure: but Burnt Lime dressed to peas.</td></tr>
</table>

This permanent experiment was laid down originally in the year 1895, but in 1906 underwent certain fundamental changes. Since 1895, however, bed No. 8 has received no potash, bed No. 3 only lime, and no farmyard manure whatsoever has been applied. As a result, effects of potash starvation are clearly evidenced,

and this despite the fact that the soil in question is a Rhine-valley loam fairly rich in potash. Best of all are the effects to be seen on bed No. 3, which received lime alone. The application of lime here, has apparently had the effect of opening up the store of potash in the soil, and has consequently, in the end, resulted in more complete exhaustion. For this reason it has been deemed expedient to publish the results of bed 3 for comparison.

Signs of potash starvation are manifested by the five crops of the rotation in varied degree: least of all by rye, somewhat more pronounced by sugar-beet, more so still by oats, and clearest of all, by far, by peas and potatoes. These differences are to be accounted for to some extent by the different needs of the plants, and to some extent by the place of the crops in the rotation. Of the plants cultivated for this experiment, the potato makes the strongest demand for potash manuring, then come in descending order: peas, oats, sugar-beet and rye. The appearance of signs of potash starvation is influenced, not only by the needs of the plants, but also by their order in the rotation. Other things being equal, more difficulty will be found in meeting the demand for potash, after crops such as sugar beet, which have marked potash-procuring properties, than after potatoes, peas etc. where such capacity for taking up potash is relatively limited.

The signs of potash starvation as shewn in the pictures are only in part characteristic. No photographs of the rye plots have been reproduced, as there, apart from a somewhat weaker growth, no typical signs of potash starvation were to

be noticed. In the case of oats (tables 1 – 6) absence of potash is marked by the greater severity of the attacks of frit-fly, a state of affairs to be accounted for by the fact, that lack of potash hinders early development, and consequently prolongs the period of susceptibility to attack. The same condition exactly is evidenced where nitrogen or phosphoric acid is present in insufficiency and also where, through various other causes, early growth has been somewhat protracted. The pea plots (tables 7 – 10) shew much more characteristic signs of potash starvation. Not long after the plants, on the plots lacking in potash, are above ground, the leaves exhibit a peculiar lightness of colour, and from this time onward the undermost ones wither off with distinctive colour change. The nature of this colour change, as distinct from normal yellowing, is admirably exemplified by Picture 10.

The symptons again in the case of the sugar-beet (tables 1 - 3, foreground) are not quite so decisive. The main effects of potash starvation here are darkness of foliage and increased tendency to suffer from aphides. The plants at harvest furthermore, tend to shew root and leaf in unfavourable proportion, and the root itself to analyse poorer in solids and sugar. The fact that starvation symptoms here, are not so strongly in evidence, is no doubt due to the extreme aptitude of the beet for procuring potash from the soil.

Especially characteristic indeed is the reaction in the case of potatoes (tables 11 - 15). In the young plant, lack of potash can be diagnosed by the striking darkness of

the green of the leaves. A little later (in June) black-grey ill-defined spots appear at irregular intervals in the mesophyll. These spots enlarge, coalesce, and bring about the premature death of the leaves, in extreme cases a pitiable sight meeting the eye — a prematurely denuded squarrulose stem bearing the almost black remains of a lamentable foliage. A kind of enforced ripeness is brought on, along with which comes, hand in hand, a falling off in yield of tubers and starch. It is also worthy of notice that where insufficient potash is present, the number of blossoms is also smaller.

The results of potash starvation in the various crops as reflected in harvests can be seen from the following table of yields per acre during the last five years:

Year	Bed No.	Manure	Potatoes cwt	Sugar beets cwt	Peas* cwt	Oats* cwt	Rye* cwt
1909	14	Complete manure	202	338	57	65	103
	8	„ without Potash	45	255	27	46	74
	3	Lime only	32	145	27	28	72
1910	14	Complete manure	186	335	24	61	57
	8	„ without Potash	100	166	14	41	53
	3	Lime only	55	201	12	31	61
1911	14	Complete manure	165	261	25	72	99
	8	„ without Potash	41	199	14	28	91
	3	Lime only	33	116	12	32	92

* Yield including straw.

Year	Bed No.	Manure	Potatoes cwt	Sugar beets cwt	Peas* cwt	Oats* cwt	Rye* cwt
1912	14	Complete manure	143	198	40	57	89
	8	„ without Potash	65	125	28	31	84
	3	Lime only	56	76	22	22	86
1913	14	Complete manure	236	—	38	127**	81
	8	„ without Potash	76	—	21	107	74
	3	Lime only	57	—	21	91	74
Average	14	Complete manure	186	283	37	76	86
	8	„ without Potash	65	186	21	51	76
	3	Lime only	46	135	18	41	77

* Yield including straw.

** Winter oats.

It must not be overlooked, that these results of potash starvation here pictorially depicted, are more or less extreme cases, and that the pictures should therefore be considered more in the light of illustrations, of the full meaning and deep reaching influence, of potash starvation in connection with plant life. It would be a fatal mistake indeed, were the farmer to wait for such evidence of insuffiency of potash in his fields: for marked diminution in yields due to potash starvation, sets in long before the typical symptoms are to be observed.

EXPERIMENTAL FIELD OF

Since 1896 manured with Lime alone and therefore exhausted of Potash

THE ROYAL AGRICULTURAL ACADEMY, BONN-POPELSDORF (Oats and Sugar-Beet).

... annually since 1896 with Complete Manure containing 89 and 107 Lbs Potash respectively

Dressed annually with sufficient ... Potash: therefo...

EXPERIMENTAL FIELD

Since 1896 manured with Lime alone and therefore exhausted of Potash

OF THE ROYAL AGRICULTURAL ACADEMY BONN-POPPELSDORF (Oats).

...e 1896 with Complete Manure containing 89 and 107 lbs Potash respectively

Dressed with sufficient Nitrogen, Phosphoric ... therefore exhausted of Potash

EXPERIMENTAL FIELD

Since 1896 manured with Lime alone and therefore exhausted of Potash

[illegible] ally since 1896 with Complete Manure containing
89 and 107 Lbs Potash respectively

Dressed annually with sufficient Nitrog [illegible]
Potash: therefore exha [illegible]

EXPERIMENTAL FIELD OF THE ROYAL AGRICULTURAL ACADEMY BONN-POPPELSDORF.

Pea Leaves.

Potash Starvation: Dressed with sufficient Nitrogen, Phosphoric Acid and Lime — Potash withheld

Dressed annually since 1896 with Complete Manure containing 89 and 107 lbs Potash respectively

EXPERIMENTAL FIELD

Since 1896 manured with Lime alone and therefore exhausted of Potash

OF THE ROYAL AGRICULTURAL ACADEMY, BONN-POPPELSDORF (Potatoes).

ally since 1896 with Complete Manure containing
89 and 107 Lbs Potash respectively

Bonn-Poppelsdorf T

Dressed annually with sufficient Nitrog
Potash: therefore exhausted of Pot

Bonn-Poppelsdorf Table 15

EXPERIMENTAL FIELD OF THE ROYAL AGRICUL

Single Potato Plants.

Complete Potash Starvation: Dressed since 1896 with Lime alone

Dressed annually since 1896 with Complete Manure containing 89 and 107 lbs Potash respectively

Potash Starvation: Dressed with sufficient Nitrogen, Phosphoric Acid and Lime — Potash withheld

URAL ACADEMY BONN-POPPELSDORF (Potatoes).

Single Potato Leaves.

Potash Starvation: Dressed with sufficient Nitrogen, Phosphoric Acid and Lime — Potash withheld

Dressed annually since 1896 with Complete Manure containing 89 and 107 lbs Potash respectively

The "E"-Field of the Agricultural Experimental Field of the University of Goettingen.

By Professor von Seelhorst, Geh. Reg.-Rat.

The Potash Syndicate recently asked permission of me for one of its officials to take colour-photographs of certain divisions of the "E-field" of the experimental field, and at the same time desired me to write a few words in explanation of the pictures. To both requests I have readily responded, as I am of opinion that such colour-photographs cannot fail to be of great educational value, provided they are accompanied by adequate description, incorporating a statement of the average yields from the various plots.

The Agricultural Experimental Field of the University of Göttingen, laid out in the year 1873, comprises some 15 acres (approx) and borders directly on the buildings of the Agricultural Institute and the Plant-breeding Garden of $2\frac{1}{2}$ acres. Its situation is therefore, all that could be desired from the point of view, both of those in charge, and of the students attending the institute. The soil may be described as a rich, deep, medium, diluvial loam. The experimental field itself is divided into ten main divisions each of some $1\frac{1}{4}$ acre (approx) in area. Seven of these divisions are laid down to a definite rotation and are cultivated on agricultural lines; the main objects in view being, firstly the growing for seed of Göttingen varieties of winter-wheat, winter-rye, and oats, and secondly, the testing of the value of new varieties of rootcrops and potatoes. The eighth, tests the value of farmyard manure and of green-manuring, while the ninth comprises the Plant-breeding garden. No. 10 is the so called "E-field", which, in the year 1874,

was put down to a permanent manurial experiment. The E-field is divided into 9 sections, which, in turn, are each subdivided into 8 plots of 60 sq. yds. (approx) area, each of which receives the same annual manurial dressing viz: —

Plot 1	of each section,	Potash, as Carbonate of Potassium,
„ 2	„ „ „	Nitrogen, as Nitrate of Soda,
„ 3	„ „ „	Phosphoric Acid, as Superphosphate,
„ 4	„ „ „	Potash, Nitrogen and Phosphoric Acid,
„ 5	„ „ „	Unmanured,
„ 6	„ „ „	Potash and Nitrogen,
„ 7	„ „ „	Potash and Phosphoric Acid,
„ 8	„ „ „	Nitrogen and Phosphoric Acid.

The different sections are separated from each other by 1 yard paths and the individual plots by ½ yard, while border plots are separated from the main paths of the experimental field by protection-belts of a breadth of 1 yard. Until the year 1897 four sections were, year in year out, laid down to the same crop, the others being cultivated in accordance with a definite rotation. In 1897, however, on account of the attacks of nematodes, the permanent cultivation of oats and peas had to be given up, and the following rotation covering all nine sections was inaugurated.

1. Peas	3. Rape	5. Mangolds	7. Kindey Beans	9. Spring Wheat
2. Rye	4. Winter Wheat	6. Barley	8. Potatoes	

Rape was replaced, first of all, by flax and later by horse-beans, so that from 1902 onwards, horse-beans follow rye, and are succeeded in turn by wheat.

Following are tabulated statistics, representative of the average annual yields per acre, of the various plots for the periods 1892 – 1903 and 1892 – 1910 respectively: –

Average Yields from the E-Field in cwts. and lbs. per Acre.

Crop	Period	Potash				Nitrogen				Phosphoric Acid				Complete manure			
		Grain		Straw		Grain		Straw		Grain		Straw		Grain		Straw	
		cwt.	lbs.	cwt.	lbs.	cwt.	lbs.	cwt.	lbs.	cwt.	lbs.	cwt.	lbs.	cwt.	lbs.	cwt.	lbs.
Rye	1892/1903	25	37	64	39	27	9	64	93	26	32	59	82	27	44	63	44
	1892/1910	26	103	66	43	28	4	66	11	28	4	64	22	28	93	67	64
Spring Wheat .	1892/1903	21	56	43	69	28	40	56	61	21	38	38	8	29	106	62	67
	1892/1910	20	97	42	95	27	9	56	43	21	21	40	69	27	110	63	80
Winter Wheat	1892/1903	29	–	70	81	34	99	74	79	26	14	52	45	34	30	82	39
	1892/1910	28	39	65	34	32	109	66	101	26	67	53	8	31	80	75	74
Barley	1892/1903	16	8	27	27	25	90	40	—	14	20	25	1	24	95	41	82
	1892/1910	14	20	23	64	23	102	36	107	11	106	21	21	23	11	38	79
Peas	1892/1903	17	5	31	9	14	109	31	42	12	65	24	6	17	58	36	89
	1892/1910	14	20	33	50	12	65	32	55	10	4	24	6	14	109	37	13
Kidney-Beans .	1892/1903	18	53	14	109	10	22	9	62	8	14	7	55	18	71	17	5
	1892/1910	19	13	15	104	10	111	9	62	9	62	8	50	18	107	18	—
Horse-beans .	1892/1903	32	37	39	92	13	78	28	57	11	35	17	5	30	12	41	100
	1892/1910	23	30	39	39	6	95	20	44	6	77	12	101	22	51	40	87
Potatoes . . .	1892/1903	183	—	—	—	172	—	—	—	150	—	—	—	233	—	—	—
	1892/1910	154	—	—	—	150	—	—	—	124	—	—	—	210	—	—	—
Mangolds . . .	1892/1903	409	—	—	—	513	—	—	—	344	—	—	—	535	—	—	—
	1892/1910	407	—	—	—	535	—	—	—	352	—	—	—	548	—	—	—

Average Yields from the E-Field in cwts and lbs per Acre.

Crop	Period	No manure				Potash + Nitrogen				Potash+Phosph.Acid				Nitrog.+Phosph.Acid			
		Grain		Straw		Grain		Straw		Grain		Straw		Grain		Straw	
		cwt	lbs	cwt	lbs	cwt	lbs	cwt	lbs	cwt	lbs	cwt	lbs	cwt	lbs	cwt	lbs
Rye	1892/1903	26	49	60	46	26	85	61	108	25	72	65	70	27	44	64	93
	1892/1910	27	27	61	21	28	4	68	7	26	49	65	34	28	4	64	39
Spring Wheat .	1892/1903	21	92	40	87	28	75	60	23	21	38	42	24	26	85	53	94
	1892/1910	21	21	42	6	26	14	57	74	21	21	43	1	25	54	54	107
Winter Wheat	1892/1903	29	88	56	61	33	52	80	49	29	106	63	62	32	109	73	18
	1892/1910	27	9	54	71	31	96	73	103	28	22	61	72	30	83	65	70
Barley	1892/1903	15	15	25	108	24	59	42	6	14	109	26	49	24	42	39	6
	1892/1910	12	65	21	38	23	47	38	79	13	60	22	87	22	69	35	76
Peas	1892/1903	11	106	24	77	17	41	37	13	16	10	30	47	15	86	32	73
	1892/1910	10	22	25	54	14	73	38	43	14	2	32	20	13	7	32	91
Kidney-Beans .	1892/1903	9	27	8	32	18	53	16	98	15	86	14	37	11	53	10	93
	1892/1910	10	4	8	85	19	84	18	54	17	41	15	50	12	65	11	15
Horse-beans .	1892/1903	13	25	19	66	30	30	43	90	31	78	41	46	13	7	28	57
	1892/1910	6	59	16	99	22	16	36	53	22	69	37	102	7	72	21	82
Potatoes . . .	1892/1903	153	—	—	—	229	—	—	—	177	—	—	—	166	—	—	—
	1892/1910	132	—	—	—	204	—	—	—	153	—	—	—	148	—	—	—
Mangolds . . .	1892/1903	354	—	—	—	537	—	—	—	378	—	—	—	468	—	—	—
	1892/1910	352	—	—	—	554	—	—	—	376	—	—	—	477	—	—	—

Attention, however, must here be drawn to the fact that these statistics and likewise the accompanying photographs, represent the results of a one-sided system

of manuring, pursued for a period covering many years, and further, that such statistics and such illustrations can properly be understood and fully appreciated, only where previous cropping is taken into consideration.

As is to be expected, where one-sided manuring has been practised, the soil of the E-field shows signs of marked impoverishment of the plant foods withheld, cf. following analytical figures:

Percentage in Soil 1901	Plot 1	2	3	4	5	6	7	8
Manure	K	N	P	KNP	O	KN	KP	NP
N	0,111	0,118	0,102	0,108	0,111	0,112	0,107	0,110
K_2O	0,553	0,445	0,391	0,523	0,452	0,555	0,578	0,472
P_2O_5	0,368	0,379	0,455	0,442	0,367	0,361	0,400	0,362
CaO	3,570	3,580	3,628	3,849	3,874	3,911	3,822	3,774

The effect of manuring in increasing or diminishing the potash supply of the soil can readily be seen by an examination of the potash contents as tabulated above. The same applies to phosphoric acid, with the exception of plot 8, and this exception, I am inclined to attribute to a mistake in the taking of the soil sample. As regards the nitrogen content, not much variation is to be observed. In explanation of the somewhat small amount of lime contained in plots 1 – 3, I would mention,

that it is probably to be accounted for, by the slope of the land. Plots 1 – 3 are situated lower than plots 4 – 8 and consequently suffer more from washing, in as much as rain, falling on the higher situated plots, will tend to trickle down the slope and find its way into the soil on the lower levels, thereby materially increasing the "rainfall" of the lower situated plots.

The percentage of potash and phosphoric acid in the soils to which these manures have not been supplied has not yet fallen so low, that an absolute lack of one or other of these constituents is probable. It is, nevertheless, to be borne in mind when considering these results, that the more soluble food constituents of the soil are first seized upon by the plant, and that consequently, in the plots manured without potash, we have before us, soil relatively poor in soluble potash.

From the above table it will be noted that there is very little variation in the nitrogen content of the various plots. It is consequently to be expected that marked results will attend the application of a nitrogenous manure.

As indications of the effect of different manurial dressings on soil composition, and consequently on plant growth, both figures and photographs are of the utmost value, showing clearly, as they do, the response of crops to a dressing of the plant food or foods present in insufficient quantity in the soil.

A glance at the accompanying tables will show how the ability to abstract food constituents from the soil, varies in the case of grain, leguminous crops, and root crops.

In contradistinction to mangolds and potatoes, grain crops find in the rich soil of the experimental field, a sufficiency of potash and phosphoric acid, even where these foods have not artificially been supplied, whereas on the other hand they are especially responsive to a dressing of nitrogen. If, in the case of winter-wheat and winter-rye, the effect is perhaps not so marked, this is to be explained by the rotation. Rye succeeds peas, and wheat, beans, and as both these crops leave the land relatively rich in nitrogen, it is only to be expected that the effects of a nitrogenous dressing will be somewhat less evident. Over and above this, it should be noted that crops dressed with nitrogen, were as a rule badly laid, and consequently did not thresh so well. With the spring-sown grain, the case is different, barley following mangolds, and spring-wheat, potatoes. There the demand for nitrogen is much greater and the effect of a nitrogenous dressing much more clearly evidenced, as may be seen from the illustrations of the barley plots. Prominence may here be given to the fact, that not only nitrogen, but also potash, has a very marked and characteristic effect on colour; a dressing of potash imparting to the plant a somewhat lighter and yellower green.

In contrast again to grain crops, the leguminosae shew practically no benefit from an artificial supply of nitrogen, with exceptions in the cases of peas and kidney-beans, where a slight increase is noted from the addition of nitrogen alone. This is explained by the fact that prior to the formation of the nitrogen-acquiring root nodules, the leguminous plant will experience a period of starvation if no available

supply of nitrogen is within its reach, and it is probably to the tiding over or the shortening of the duration of this critical period, that the above beneficial effect of a nitrogenous dressing is to be attributed. Of special importance is this, in the case of peas, as during the starvation period the young plants tend to suffer very badly from attacks of the Striped Pea-weevil (Sitones lineatus), and a diminution in the length of the starvation period will necessarily involve a consequent diminution in the length of the period of the attack.

Remarkable indeed is the demand made by the leguminosae for potash. Whereas grain crops have done fairly well where no potash is supplied, leguminous plants have suffered badly, and shew, one and all, unmistakable signs of potash-starvation. The demand for potash is most strongly evidenced in the case of kidney-beans and horse-beans, and not quite so much so in that of peas, a state of affairs to be explained to some extent by the fact, that the peas on the experimental field never come to full ripeness; the young shoots, young peas, and blossoms being destroyed by the attacks of thrips, which make their appearance generally about the beginning of July.

The abnormal demand made by horse-beans for potash in soluble form, is well illustrated by the accompanying photographs, although the stunting of the young shoots, and the cramped, curled-up, and somewhat horizontal habit of growth of the leaves is a trifle difficult to distinguish. There is also not much effect to be observed on colour.

So far as potatoes and mangolds are concerned, results vary somewhat. The potato harvest shews a slight improvement both from a potassic dressing and from a nitrogenous dressing, as against no manure; but here again the full advantage of the potash could not be derived in the presence of insufficient nitrogen, and contrariwise the action of the nitrogenous fertiliser was hampered considerably by the absence of an adequate store of soluble potash. Only where potash and nitrogen were applied together, was a really distinct improvement to be observed. The effect of potash on the crops is easily seen from the photographs, the foliage being of a much lighter shade where potash has been applied, and the green a much yellower one. Best of all perhaps is this brought out by the plot which received potash alone. The complete manured, the potash-nitrogen, and the potash-phosphoric acid plot illustrations are, however, also very characteristic, and especially so if placed alongside those of the dark-green foliaged nitrogen and phosphoric acid plots.

The experimental field, which is rich in potash shews, that in the case of mangolds, the demand of which for large quantities of potash is now an accepted fact, the influence of nitrogenous manuring exceeds by far, the influence of potash manuring.

From this we may readily infer, that the powers of mangolds for obtaining potash from the soil are much greater than those of potatoes; for whereas in the case of mangolds, practically the full yield is obtained where a nitrogenous fertiliser

alone is applied, a full yield of potatoes is not produced unless the nitrogen is dressed in conjunction with potash.

From these statements it follows that the statistics and illustrations here given indicate the needs of the various plants for the different plant-foods and of the abilities of the individual crops to abstract the individual foods from the soil. These experiments are therefore not necessarily to be taken as hard and fast examples of how manuring should be conducted in actual farm practice.

On ordinary farm land the results of manuring can scarcely be expected to be as marked as on the E-field, where the different plots have each been treated in the same way year after year for a considerable period.

The failure of phosphoric acid in these experiments must be accounted for, solely by the fact, that the soil is especially rich in phosphoric acid: the phosphoric acid plot in comparison with the unmanured, and the nitrogen-phosphoric acid in comparison with the bare nitrogen, having indeed as a rule shewn a slight decrease in yield. The addition of a large store of phosphate where potash and nitrogen are present in insufficient quantity will in this case naturally have a detrimental effect on plant growth, in as much as the balance of foods in the soil will more than ever be disturbed. Under such circumstances the yield can be expected to be maintained only where in addition to the phosphoric acid a proportionate supply of potash and of nitrogen is also administered.

PERMANENT MANURIAL EXPERIMENT

Plot 1

Manured with Potash

Plot 2

Manured with Nitrogen

ON THE E-FIELD OF THE AGRICULTURAL EXPERIMNTAL FIELD, GÖTTINGEN (B...

...sphoric Acid

Plot 4

Manured with Nitrogen,
Phosphoric Acid and Potash

Plot 5

Unmanured

PERMANENT MANURIAL EXPERIMENT ON THE E-FIELD OF THE

Plot 4

Manured with Nitrogen, Phosphoric Acid and Potash

Plot 5

Unmanured

AGRICULTURAL EXPERIMENTAL FIELD, GÖTTINGEN (Barley).

Plot 7

Manured with Potash
and Phosphoric Acid

Plot 8

Manured with Nitrogen
and Phosphoric Acid

PERMANENT MANURIAL EXPERIMENT

Plot 1

Manured with Potash

Plot 2

Manured with Nitrogen

ON THE E-FIELD OF THE AGRICULTURAL EXPERIMNT FIELD, GÖTTINGEN (Horse Beans).

Ma... ...oric Acid

Plot 4

Manured with Potash, Nitrogen, and Phosphoric Acid

Plot 5

Unmanured

Göttingen Table

Göttingen Table 1

PERMANENT MANURIAL EXPERIMENT ON THE E-FIELD OF THE

Plot 4

Manured with Potash, Nitrogen and Phosphoric Acid

Plot 5

Unmanured

AGRICULTURAL EXPERIMENTAL FIELD GÖTTINGEN (Horse Beans).

Plot 7

Manured with Potash
and Phosphoric Acid

Plot 8

Manured with Nitrogen
and Phosphoric Acid

PERMANENT MANURIAL EXPERIMENT

Plot 1

Manured with Potash

ON THE E-FIELD OF THE AGRICULTURAL EXPERIMENTAL FIELD, GÖTTINGEN (Potatoes)

Plot 2

Manured with Nitrogen

P

Manured with Pho

PERMANENT MANURIAL EXPERIMENT

Plot 5

Unmanured

ON THE E-FIELD OF THE AGRICULTURAL EXPERIENTAL FIELD, GÖTTINGEN (Pot

Plot 4

Manured with Nitrogen
Phosphoric Acid and Potash

Plot

Manured with Nit
and Phosphoric Ac

PERMANENT MANURIAL EXPERIMENT ON THE E-FIELD OF THE

Plot 6

Manured with Potash and Nitrogen

AGRICULTURAL EXPERIMENTAL FIELD, GÖTTINGEN (Potatoes).

Plot 7

Manured with Potash
and Phosphoric Acid

Göttingen Table 18

Agricultural Experiment Station,

Institute of the "Landwirtschaftskammer" for the Province of Saxony,

Halle a. S.

Manurial Experiments with a view to determining the Balance of Plant Foods in the "Loess" Soil of the Experimental Farm, Lauchstädt.

Prof. Schneidewind, Ph. D. Halle.

These manurial experiments present, year by year, an interesting picture. The object in view is the determination, by permanent experiment, of the effect of potash manuring on the following crop rotation: Sugar-beet, Barley, Potatoes and Wheat. Sugar-beet and potatoes on the potash plots receive an annual dressing at the rate of 107 lbs. potash per acre (2 cwts. 43 lbs. of 40 % Potash Manure Salts per acre) and the wheat and barley at the rate of 71 lbs. potash per acre (1 cwts. 66 lbs. 40 % Potash Manure Salts per acre). The effect of potash is tested, on the one hand on plots never dressed with dung, and on the other hand on plots where dung is applied at the rate of 8 tons per acre with beets and potatoes, while barley after beets and wheat after potatoes receive no dung. Deep-box dung was used, and hence dung of the best quality, with the liquid, the source of the soluble potash, well preserved. It is not to be wondered, therefore, that as yet no effect due to potash has evidenced itself on the plots which received dung; the soil being "Loess" rich in potash and in humus, while on the plots dressed with artificials alone, potash has produced each year, most marked results. The following are the average annual yields per acre:

1. Wheat.

	Grain	Straw
Nitrogen + Phosphoric acid + Potash . .	29 cwts. 60 lbs.	56 cwts. 89 lbs.
Nitrogen + Phosphoric acid	25 ,, 68 ,,	51 ,, 65 ,,
Increase due to Potash	3 cwts. 104 lbs.	5 cwts. 24 lbs.

An increase of 3 cwts. 104 lbs. per acre is good testimony to the advantage of potash manuring for wheat growing.

2. Barley.

	Grain		Straw	
Nitrogen + Phosphoric Acid + Potash .	26 cwts.	16 lbs.	35 cwts.	24 lbs.
Nitrogen + Phosphoric Acid	25 „	31 „	34 „	13 „
Increase due to Potash	0 cwts.	97 lbs.	1 cwts.	11 lbs.

Barley therefore does not shew as great a demand for potash as wheat; but it must here be noted, that barley on the potash plots has invariably proved of better quality, than where grown without potash.

3. Potatoes.

	Tubers		Starch		
			Per Cent	Per Acre	
Nitrogen + Phosphoric Acid + Potash	176 cwts.	23 lbs.	17.27 %	30 cwts.	49 lbs.
Nitrogen + Phosphoric Acid	126 „	26 „	17.66 %	22 „	39 „
Increase due to Potash	49 cwts.	109 lbs.	0.39 %	8 cwts.	10 lbs.

The above figures exemplify well the extraordinary demand made by the potato for available potash, an increase of 49 cwts. 109 lbs. tubers, with 8 cwts. 10 lbs. starch per acre being directly attributable to potash manuring.

4. Sugar-Beet.

	Roots		Sugar			Leaves	
	Cwts.	lbs.	%	Cwts.	lbs.	Cwts.	lbs.
Nitrogen + Phosphoric Acid + Potash	331	80	17.93	59	63	259	82
Nitrogen + Phosphoric Acid	323	98	17.31	55	98	254	53
Increase due to Potash	7	94	0.62	3	87	5	29

These results go to shew that, though the sugar-beet needs a much greater quantity of potash for its growth, it nevertheless makes less demand for potash manuring than does the potato. The increase in yield of roots due to potash was only some 8 cwts. per acre, but here again quality must be taken into consideration: by the dressing of potash, the sugar content was raised by 0,62 % making a total increase equivalent to an amount of 3 cwts. 87 lbs. sugar per acre.

The Balance of Potash in the Soil.

An average for the period shews that the annual amount of potash withdrawn from the soil, is in excess of that applied.

	Potash in lbs. per acre per year.
Unmanured	— 64 lbs.
Complete artificial manuring	— 27 ,,
Dung alone	— 42 ,,
Dung and complete artificial manuring	+ 7 ,,

From these statistics it will be observed, that from the plots dressed with complete artificial fertiliser, 27 lbs. more potash was taken up by the plants, than was added

to the soil. The plots treated with farmyard manure alone shewed a deficit of 42 lbs. per acre, while, where complete artificials were applied along with dung, a slight increase was indicated. In as much as here, by combined dressing of dung and potash, quantities of potash much in excess of those used in every day farm practice, have been administered to the soil, and further, in as much as certain quantities of potash are washed out of the soil by drainage, it may with reason be asserted, that in the farming of better class soils, so far as potash is concerned, a system of soil impoverishment is practised. This soil impoverishment is perhaps, to a limited extent, to be approved on richer land, but the fallacy of advocating and practising it beyond that limit; of neglecting potash in the farming of better soils, is exemplified in striking manner by the permanent experiments of the Lauchstädt Station. Even when dunged with large quantities of the best farmyard manure, the very richest soils will sooner or later shew unmistakable results of the system of soil impoverishment followed.

The illustrations shew:

1. that in the case of Cereals, the crop is shorter and the period of growth longer: the potash plots are of a golden yellow while the no-potash plots are still quite green.
2. that in the case of potatoes, in the absence of sufficient potash, the leaves assume a dark green colour which later changes to brown, while where potash is present in sufficiency the leaves have a fresh-green appearance and retain their colour until the crop is ripe.

ROTATION EXPERIMENT WITH MANURES, FROM

Plot permanently without Farm Yard Manure

Manured with Nitrogen, Phosphoric Acid and Potash

THE EXPERIMENTAL FARM, LAUCHSTÄDT.

Plot permanently without Farm Yard Manure

Manured with Nitrogen and Phosphoric Acid

ROTATION EXPERIMENT WITH MANURES, FROM

Plot permanently without Farm Yard Manure

Manured with Nitrogen, Phosphoric Acid and Potash

THE EXPERIMENTAL FARM, LAUCHSTÄDT.

Plot permanently without Farm Yard Manure

Manured with Nitrogen and Phosphoric Acid

ROTATION EXPERIMENT WITH MANURES, FROM THE EXPERIMENTAL FARM, LAUCHSTÄDT.

Plants from plots without Farm Yard Manure

Unmanured

Manured with Nitrogen, Phosphoric Acid and Potash

Manured with Nitrogen and Phosphoric Acid